

**Exhibit 9** to the Request for *Inter Partes* Re-examination of

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**Title: Variable-Conductance Sensor**

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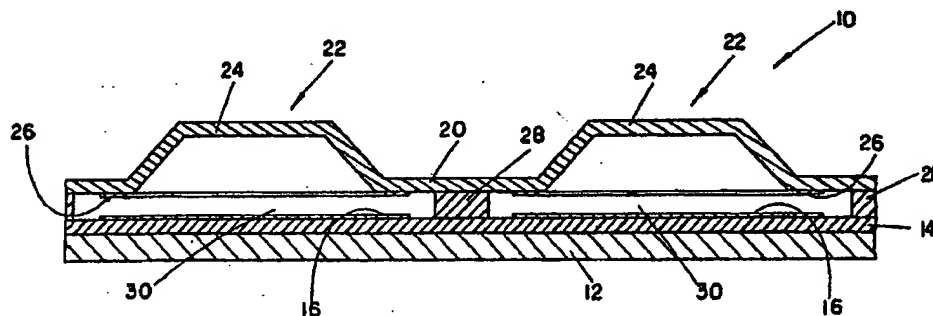
(58) Field of search

H1N

## (54) Membrane switch

(57) A membrane switch assembly includes a stationary membrane switch circuit layer (16), an insulating spacer (28) or separator on the stationary membrane layer having at least one opening therethrough (30) and a movable membrane layer switch circuit on the other side of the spacer having at least one snap-action tactile element (22) extending upwardly therefrom. The stationary membrane layer has electrical conductors (16) thereon arranged in a geometrical pattern and cooperating with the openings (30) in the separator layer (28) to define an array of unique switch and circuit locations. The movable layer has a conductive contact surface 26 located on the flat surface thereof along the periphery of a tactile element (22), preferably as an annular ring, or as segments.

FIG. 3



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FIG 1

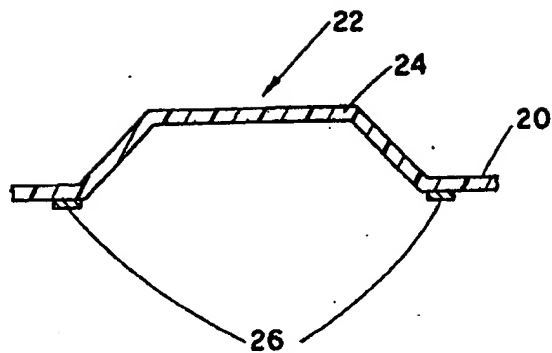


FIG 2

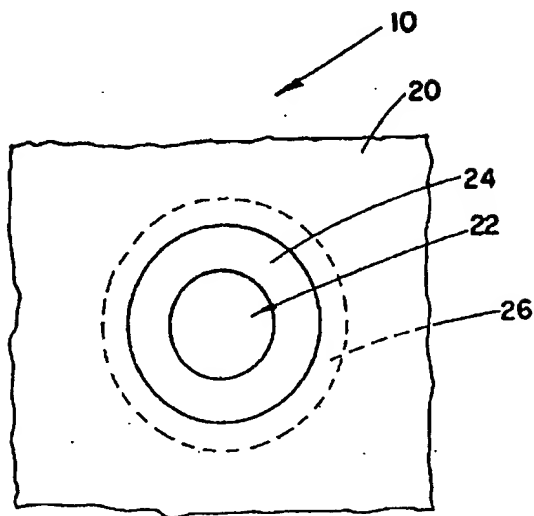


FIG. 2A

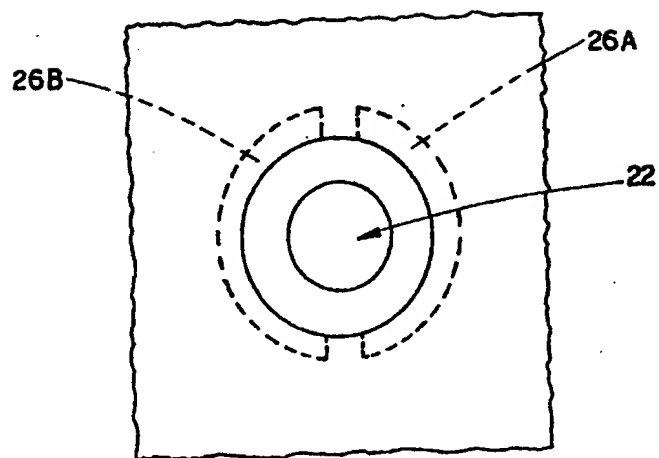
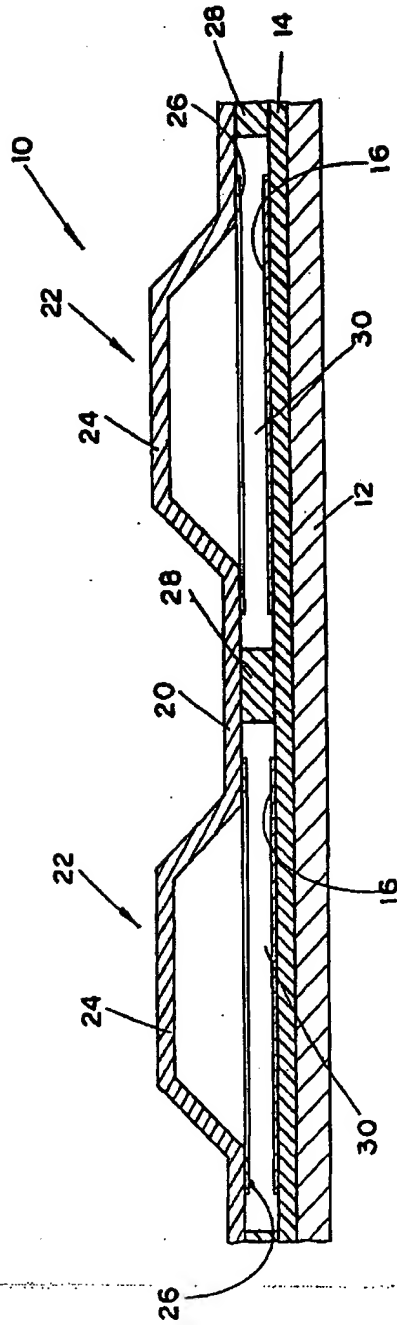


FIG. 3



## SPECIFICATION

## Membrane switch

5 This invention relates to tactile membrane keyboards. More particularly, this invention relates to tactile membrane keyboards having a strong tactile snap effect and an extremely long functional life.

10 Tactile membrane keyboards have found increasing use and acceptance in many commercial and domestic applications. Thus by way of example only, the keyboard has found utility in retail outlets, airline terminals, fast-food restaurant terminals, data terminals, calculators, and any other apparatus wherein digital input is necessary.

A conventional keyboard includes an array of keys which may be individually actuated to close a pair of contacts of an electrical circuit associated with each of the keys. It is often considered desirable to provide for tactile feedback so that, when the keys are pressed by the finger of a person operating the keyboard, the keys "snap" and force discontinuity is transmitted to the finger of the user indicating that the key has been actuated and an electrical signal thus generated in the circuit associated with the key.

30 A typical membrane type keyboard having tactility as described above is comprised of a membrane switch assembly which includes a bottom stiffener layer, a stationary membrane switch circuit layer on the stiffener, an insulating spacer or separator on the stationary membrane layer, and an active membrane switch circuit layer on the other side of the spacer. This active membrane layer is often comprised of a plurality of tactile snap-action elements such as domes which extend upwardly therefrom away from the lower stationary membrane layer. Both the stationary and active membrane layers have electrical conductors thereon (formed by printed circuit techniques such as conductive ink) arranged in a desired pattern and cooperating with holes or openings in the separator layer to define an array of unique switch and circuit locations. The application of an appropriate force to a switch site (i.e., tactile dome) on the upper surface of the active layer causes the active layer and its particular switch component to make mechanical and electrical contact through the appropriate hole in the spacer with the circuit pattern on the fixed or passive layer of the membrane.

Conventional prior art tactile membrane keyboards have a problem of a lack of reliability and uniformity in the operational or functional lifespan (i.e., number of actuations before failure) of tactile domes. To a great extent, this problem appears to result from a degradation or breakdown of the conductive ink on the active membrane layer. It is hypothesized that stress and fatigue from the con-

tinued flexing or actuating of the tactile dome eventually causes the degradation of the conductive material (e.g., ink) located on the inside surface of the dome. Thus, after such a

70 breakdown, the tactile dome, which serves as the contact medium for conventional keyboards, will no longer effect adequate electrical contact. Breakdown of the conductive materials on the contact surface of the active layer either require the keyboard to be discarded or will create undesirably increased maintenance, replacement and labor costs for repair. Accordingly, a tactile membrane keyboard which not only retains adequate tactile (snap-action) feedback, but also has an improved or extended operating life would be highly desirable and advantageous.

In accordance with the present invention, there is provided a membrane switch comprising a first circuit sheet, said first circuit sheet having at least a first sheet of insulating material with first electrically conductive contact means thereon, a said second sheet having a second sheet of insulating material, at least one tactile element formed in and extending from said second sheet, said second sheet of insulating material defining a flat surface at the base of said tactile element, second-electrically conductive contact means on said flat surface about the periphery of said tactile element, spacer means between said first and second circuit sheet, said spacer means having a plurality of openings therein whereby said tactile element is actuatable under an applied force to move said second conductive contact means through said opening and into electrical contact with said first conductive contact means.

As in the prior art keyboards, the lower stationary membrane layer has a contact area of electrical conductors (e.g., copper traces or conductive ink) thereon arranged in a pattern and cooperating with holes in the separator layer to define an array of unique switch and circuit locations. Unlike the prior art, a novel improvement of the present invention lies in the positioning and structure of the contact surface of the active layer. This novel contact surface, which may be comprised of conductive ink or other conductive material, is applied to the active layer, around the periphery of the base of a dome on the flat surface of the active layer, preferably as an annular ring. Thus, as no part of the upper contact ring surface is adhered to the flexing surface of the dome as in the prior art, the conductive material comprising the contact surface will not be subject to the previously discussed stress or fatigue and resultant breakdown when the dome is repeatedly actuated over a long period of time. The tactile membrane keyboard of the present invention, therefore, exhibits a markedly improved and extended operating life which in turn, provides improved efficiency and greater reliability and

economy to the keyboard purchaser and manufacturer. Note that the present invention requires the use of less conductive ink than in the prior art and therefore reduced manufacturing costs.

In order to accomplish this modified annular contact structure along the periphery of the domes, the diameter of the openings in the spacer or separator is increased relative to conventional keyboards. Similarly, the contact area of the lower stationary layer is correspondingly increased to equal that of the openings. Thus, sufficient room is provided for the annular contact rings on the active layer so that, upon actuation of the dome, the annular ring will have an open path to effect contact with the electrical conductors on the stationary layer. The particular structural arrangement of the present invention provides electrical contact prior to the dome having travelled its full course, with the full travel of the dome and snap action or tactile feedback telling the operator that switch actuation has occurred.

Various modifications and embodiments of the tactile membrane keyboard of the present invention include segmenting one or both switch contact surfaces in order to permit multiple parallel contacts on both the upper and lower circuit layers. Also the present invention is equally applicable to a multiplicity of dome configurations including, but not limited to, oval domes and ramp-shaped domes. Finally, the absence of conductive material along the inside surface of the snap-action dome permits the incorporation of back-lighting, i.e., illumination from beneath the keys.

The above-discussed and other advantages of the present invention will be apparent to and understood by those skilled in the art from the following detailed description and drawings.

Referring now to the drawings, wherein like elements are numbered alike in the several figures:

*Figure 1* is a partial cross-sectional elevation view of the upper portion of an individual tactile membrane element in accordance with the present invention.

*Figure 2* is a plan view of the tactile dome of Fig. 1 in accordance with the present invention.

*Figure 2A* is a view similar to Fig. 2 of a modified construction.

*Figure 3* is a cross-sectional elevation view showing a tactile membrane keyboard assembly in accordance with the present invention.

Referring to the Figures, a portion of a keyboard in accordance with the present invention is shown. In the Figures, one or two key locations are shown, but it will be understood that an entire keyboard is made up of a monolithic membrane circuit structure comprised of any number of individual tactile domes or keys, the specific number being

determined by the requirements of the particular keyboard and application.

A two key portion of a monolithic membrane keyboard or circuit array 10 is shown in Fig. 3. The monolithic membrane keyboard or switch structure includes a bottom stiffener sheet or rigidizing layer 12 which may be a plastic or metal sheet with stiffness and flatness equivalent to aluminum 6061 alloy of approximately 0.5 mm thick. Stiffener 12 serves to support and maintain in planar condition a fixed or passive layer circuit sheet of the key switch assembly which consists of a lower insulating layer or sheet 14, preferably of Mylar polyester film, and a lower circuit pattern 16 formed thereon. This fixed or passive key switch layer or circuit sheet is adhesively bonded to stiffener 12. Insulating layer 14 may be of any desired thickness, preferably between 0.05 mm to 0.18 mm and the conductive pattern thereon may be formed by any known printed circuit technique, such as by printing with a conductive ink, printing or etching a conductive metal foil, etc. Preferably, the conductive pattern 16 should be reasonably thin (on the order of 0.01 to 0.05 mm in thickness, and preferably about 0.025 mm thick).

A movable or active switch layer or upper circuit sheet is positioned above the lower circuit pattern 16. The movable or active switch layer comprises an upper insulating layer 20, e.g. Mylar. The upper insulating layer 20 has an array of snap-action protrusions or tactile elements 22 in the shape of an arcuate dome 24 of truncated cone shape having a flattened top surface. As mentioned, the present invention is equally applicable to tactile domes of other shapes including, but not limited to, semispherical domes, oval-shaped domes, ramp domes, etc. The insulating layer 20 of the active switch layer has a printed circuit conductor or contact surface 26 having the shape of an annular ring and formed by any known printed circuit technique (e.g., conductive ink). This annular ring-shaped contact surface 26 runs around the outer periphery of the dome 24 base and is adhesively or otherwise bonded to the flat surface of the active switch layer.

An insulating spacer or separator layer 28 having a plurality of openings 30 may be adhesively or otherwise fixed in position on one side to the stationary layer on which the lower circuit pattern 16 is located, and on the other side to the upper insulating layer 20. The total thickness of the spacer 28 may be used to adjust the distance between the upper conductor 26 and the lower circuit pattern 16. The opening 30 in spacer 28 must be larger than the diameter or outer dimensions of conductor pattern 26 so as to allow the dome 24 to snap through and deflect pattern 26 into contact with the circuit pattern 16 in order to achieve electrical contact between the

switch components.

The array of flat-top arcuate domes 24 and correspondingly bonded annular ring-shaped circuit conductors 26 are positioned above the lower circuit pattern 16 such that the domes 24 protrude upwardly away from the lower circuit pattern. This arrangement defines an array of unique circuit locations or switch sites. When a force of sufficient magnitude is imposed on a dome 24, the protrusion 22 is moved downwardly in a snap-action through the opening 30 in spacer 28 moving the annular contact surface 26 into electrical and mechanical contact with the lower circuit pattern 16. This electrical contact acts to close a switch and deliver an electrical signal. It should be understood that the novel design of the present invention results in electrical contact taking place between the respective contact surfaces 16 and 26 prior to the dome having travelled its full course. Nevertheless, the necessary tactile feedback is achieved as the dome will continue in its travel path, resulting in snap action whereby the keyboard operator perceives that contact has been accomplished.

As discussed earlier, a major problem in conventional prior art membrane keyboards has been a lack in reliability and predictability of the functional lifespan of the keyboards. This problem is overcome by the membrane keyboard of the present invention. While in the prior art, the upper conductive contact surface was adhesively applied to the inside of a dome, in the present invention, the upper conductive surface 26 is formed preferably as an annular ring on the flattened surfaces of insulating layer 20 (as opposed to the flexing area within the dome). The advantage of the annular conductive surface 26 is far decreased stressing fatigue and less flexing of the surface 26. In other words, since no part of the contact ring surface 26 is adhered to any surface of the dome 24, the surface 26 will not be subject to the repeated stressing and flexing of the inner surface of the dome 24 during key actuation. The lower fatigue associated with the present invention therefore results in longer life of the active contact element.

Another difference between the present invention and the prior art is the comparative dimensioning of the openings 30 in spacer 28 and the lower contact surface 16 on the passive layer 14. In order to construct a membrane keyboard in accordance with the present invention, the relative dimensioning of the component parts has to be such that the upper annular contact surface 26 can freely make electrical and mechanical contact with the lower contact surface 16, while the plurality of domes 24 retain the required tactile, snap-action feature. Accordingly, the diameter of the openings 30 in the spacer 28 is increased relative to the prior art spacer open-

ings. Similarly, the diameter of the lower contact surface 16 on lower insulating layer 14 is correspondingly increased. Thus, the annular flat area on the inside surface of insulating layer 20 capable of supporting annular contact surface 26 is exposed to the lower contact surface 16 so that contact may be effected therebetween.

In an alternative embodiment of the present invention, the contact surfaces 16 and 26 may be segmented so as to permit multiple, parallel contacts on both the upper and lower membrane layers. The segmented upper contact surface is shown in Fig. 2A, where the tactile element or dome 22 is surrounded by arcuate contact segments 26a and 26b. The contact surface 16 would be similarly segmented. This segmented configuration is very difficult, if not impossible to accomplish with conventional tactile membrane keyboards wherein the upper contact surface is secured to the inside surface of the dome.

The tactile membrane keyboard of the present invention is extremely economical for both the purchaser and manufacturer. The improved operational lifespan and greater reliability translates into far lower replacement and maintenance costs. Similarly, from the manufacturer's standpoint, the annular ring of conductive ink, paint or other conductive surface requires less material than in the prior art. Also, if the conductive contact surface 16 on the lower passive layer is shaped like an annular ring of the same configuration as the annular ring 26 on the active layer (rather than a full contact pad), then even less conductive ink or the like will be needed at a great cost savings.

A further advantage of the present invention is the possibility of illuminating the key legend from beneath the keys. In the prior art, the presence of conductive ink or the like underneath the dome prevented a light source from penetrating therethrough. Since, in the present invention, conductive ink is only around the periphery of each key, it is not in a position to block light transmission through the key and therefore backlighting illumination may easily be provided if so desired.

#### CLAIMS

1. Membrane switch comprising:
  - a first circuit sheet,
  - said first circuit sheet having at least a first sheet of insulating material with first electrically conductive contact means thereon,
  - a second sheet having a second sheet of insulating material,
  - at least one tactile element formed in and extending from said second sheet
  - said second sheet of insulating material defining a flat surface at the base of said tactile element,
  - second electrically conductive contact means on said flat surface about the periphery



of said tactile element.

spacer means between said first and second circuit sheet,

said spacer means having a plurality of

- 5 openings therein whereby said tactile element is actuable under an applied force to move said second conductive contact means through said opening and into electrical contact with said first conductive contact means.

- 10 2. A membrane switch as claimed in Claim 1, wherein said tactile element is a snap-action dome.

3. A membrane switch as claimed in Claim 2, wherein said snap-action dome has  
15 an arcuate shape with a flat top.

4. A membrane switch as claimed in any one of Claims 1 to 3, wherein said second conductive contactor means has an annular shape.

- 20 5. A membrane switch as claimed in Claim 4, wherein said first conductive contactor means has an annular shape corresponding to said second conductive contactor means.

- 25 6. A membrane switch as claimed in any one of Claims 1 to 5, wherein said first and second conductive contactor means are comprised of a conductive ink.

- 30 7. A membrane switch as claimed in any one of Claims 1 to 6, wherein said first and second conductive contactor means are segmented thereby permitting multiple parallel contacts on said upper and lower circuit sheet means.

- 35 8. A membrane switch as claimed in any one of Claims 1 to 7, including a stiffening sheet in supporting attachment to said lower circuit sheet means.

- 40 9. A membrane switch as claimed in any one of Claims 1 to 8, wherein said tactile element is free of electrically conductive material within the periphery of said tactile element, whereby said tactile element is suitable for backlighting.

- 45 10. A membrane switch substantially as hereinbefore described and as illustrated in the accompanying drawings.